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MAY 1988

A TEMPORAL COMPARISON OF SURVIVORSHIP
PATTERNS IN THREE SPECIES OF
CAPTIVE CETACEANS

By

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ADMINISTRATIVE REPORT LJ-88-14

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TABLE OF CONTENTS

	Page
ABSTRACT.....	1
INTRODUCTION.....	1
METHODS.....	1
RESULTS.....	4
Killer whales.....	4
White whales.....	4
Bottlenose dolphins.....	4
DISCUSSION.....	5
ACKNOWLEDGEMENTS.....	7
LITERATURE CITED.....	8

LIST OF TABLES

	Page
TABLE 1. Summary of the five year comparision of survival rates for captive killer whales. Data are from the National Marine Fisheries Service's Marine Mammal Inventory Report.....	9
TABLE 2. Summary of the five year comparision of survival rates for captive white whales. Data are from the National Marine Fisheries Service's Marine Mammal Inventory Report.....	9
TABLE 3. Summary of the five year comparision of survival rates for captive Bottlenose dolphin. Data are from the National Marine Mammal Service's Marine Mammal Inventory Report.....	10
TABLE 4. A comparison of survival rates over two five year time spans analysis for captive bottlenose dolphins by sex*. Data are from the National Marine Fisheries Service's Marine Mammal Inventory Report.....	10

LIST OF TABLES (continued)

TABLE 5.	A comparison of survival rates over two five year time spans analysis for captive bottlenose dolphins by taketype. Data are from the National Marine Fisheries Service's Marine Mammal Inventory Report.....	11
TABLE 6.	A comparison of survival rates over two five year time spans analysis for captive bottlenose dolphins by sex. Data are from the National Marine Fisheries Service's Marine Mammal Inventory Report.....	11

LIST OF APPENDICES

APPENDIX 1.....	12
APPENDIX 2.....	13
APPENDIX 3.....	15
APPENDIX 4.....	16
APPENDIX 5.....	17
APPENDIX 1.....	18

ABSTRACT

A comparison of survival patterns of three species of captive cetaceans between two five year periods (1975-1979 vs. 1980-1984) is reported based on data from the Marine Mammal Inventory Reports. Survival rates of killer whales (Orcinus orca) and white whales (Delphinapterus leucas) were not significantly different between the two time spans. Bottlenose dolphins (Tursiops truncatus) did have significantly different ($\chi^2=12.58$) survival rates between the two time spans. Survival rates of female bottlenose dolphins improved significantly during the ten year study period, while male survival rates did not change significantly.

INTRODUCTION

The increase in the popularity of marine mammals has brought with it new concerns for the ethics of maintaining marine mammals in captivity. The question arises as to the longevity of captive versus free-ranging cetaceans. The Marine Mammal Protection Act of 1972 set up strict guidelines as to the capture and holding of these animals in the United States. Several studies were done on survivorship of captive marine mammals but comparisons of the results are confounded due to the various methodologies used (Hui and Ridgway, 1974; Bigg and Wolman, 1975; Walker, 1975; Best and Ross, 1984; Greenwood and Taylor, 1985; DeMaster and Drevenak, 1988.).

Previously DeMaster and Drevenak (1988) reported that the survival of three species of captive cetaceans varied between institutions. Wimer (1988) reported that survival patterns in captive sea lions (Zalophus californianus) varied by geographical area. Furthermore, Walker (1975) described several problems involved in the capture and acclimation of six species of cetaceans to captivity.

The purpose of this study was to establish whether any differences in the captive survival rate of three species of marine mammals (bottlenose dolphin, Tursiops truncatus, killer whale, Orcinus orca, and white whale, Delphinapterus leucas) have occurred over a ten year period (1975-1984). If survival rates have changed over this time period, the evaluation of an institution's husbandry practices for these three species would have to take this change into account. For example, the pooling of all animal-days reported by DeMaster and Drevenak (1988) would not be valid if the survival rates were not constant over time.

METHODS

The data for this study were provided by the National Marine Fisheries Service, in the form of Marine Mammal Inventory Reports. Data from these reports were entered into a data base using DBASE III PLUS. The data base included the following for

each individual: age, sex, taketype, date of acquisition and date of death or transfer, if applicable. All of this information was provided for 864 dolphins, 71 killer whales, and 48 white whales.

The data were processed into a usable form using a dbaseIII program called SETDATA.PRG (Appendix 1). The processed data were then separated into two time spans, 1975-1979 and 1980-1984, using a program called TIMESPAN.PRG (Appendix 2). If the date of death was before January 1, 1975 or the date of acquisition was after December 31, 1984 the individual was not included in the study. Only the days that an individual spent within each span were included. The number of days survived within a time span was calculated from two programs, DATEDIF.PRG (Appendix 3) and DAYS.PRG (Appendix 4) (a modified version of a program reported by Poole et al.(1981)). The number of deaths for each time span was calculated using STATS.PRG (Appendix 5).

The method for estimating rates of survival was taken from Trent and Rongstad (1974). This technique is similar to the estimator used by Mayfield (1975), except that the information is available on a daily basis. Hui and Ridgway (1978) used a method for estimating survivorship that was based on the fraction of years survived rather than on the fraction of days survived. This method was not used because the notation is difficult to follow and this approach is often misapplied in the literature (i.e., Greenwood and Taylor, 1985).

The following methodology was used to calculate annual survival rates (ASR's):

$$DSR = 1 - \sum [(y_i)/(x_i)] \quad (1)$$

$$ASR = DSR^{365.25} \quad (2)$$

where DSR is the daily survival rate, y_i is one if the i th individual died during the time span and zero if the i th individual survived through the entire time span, x_i is the number of days in captivity for the i th individual, and n is the number of animals in the sample.

There are two assumptions that must be met in using this method (Trent and Rongstad, 1974): (1) the death of one individual does not affect the probability of another individual surviving and (2) the probability of surviving each day remains constant. If these two assumptions are met and because each animal-day can only have one of two outcomes, survival or death, each individual animal-day is a binomial event and the distribution of deaths over a given reporting period will be distributed binomially.

A 95% confidence interval for the DSR was calculated directly from a binomial distribution, where the binomial parameter was set equal to $(1-DSR)$ and n was set equal to the total number of animal-days. The upper and lower limits for the number of deaths were interpolated to the nearest 0.01 animal. The limits were raised to the 365.25 power to determine the confidence interval for the ASR. (See DeMaster and Drevenak, (1988) for a detailed discussion.)

For most of the calculations, the lower and upper limits for the expected number of deaths were calculated directly from the binomial distribution, given a certain number of deaths and animal-days. However, because of machine limitations in handling large factorials, a normal approximation was used to estimate the upper limit when the number of deaths was greater than five, as was done by DeMaster and Drevenak (1988). In this approximation, it is assumed that the standard deviation of the expected number of deaths equals the square root of the observed number of deaths. Differences between the survival rates for the period were tested using the variance test for homogeneity of the binomial distribution (Snedecor and Cochran, 1967). The variance test was used in a dbaseIII program called SUMSTATS.PRG (Appendix 6).

The two five year time spans were further compared by stratifying the survival data by sex and taketype. When stratified by sex, two groupings were possible: male and female. Male survival rate of the first time span was compared to the male survival rate of the second time span. This comparison was also done for the female survival rates.

Ten groupings were possible when the survival data was stratified by taketype. Of the ten groupings, only two groups could be utilized in the comparison of the survival rates between two five year time spans. The groups were captive born (CB) and held permanently (HP). These two groups represented populations that were held in only one institution at that time in their life in captivity. Any individual that had been transferred or exchanged (EX) had been put through the added stress of transport and re-acclimation to a different institute. BS (stranded or beached) individuals represented a possibly unhealthy population that had been taken into the captive environment. This would tend to bias the survival rate estimate. Other groups were not considered because the capture and/or keeping of the individuals was outside of the United States and may not adhere to standards set in the Marine Mammal Protection Act of 1972.

HP individuals are those that were wild caught in the U.S. and transferred directly into the U.S. institution in which they are listed. Because they were born in the wild, they had to go through a period of acclimation in their new captive environment. The level of stress involved in the capture and acclimation may have an affect on the captive survival rate. Differences in

survival rates may reflect possible changes in the acclimation process of individuals.

CB individuals are those that were born in captivity within the U.S. and have remained in the same institution up to that point. They have had a minimal level of stress applied to them and should be the ideal captive individual in which to study changes in husbandry practices.

RESULTS

Killer whales

The annual survival rate of the 71 captive killer whales that were in captivity between 1975-1979 was 0.93 (Table 1). The 95% confidence interval was 0.88 - 0.99. The annual survival rate for animals in captivity between 1980-1984 was 0.93 with a 95% confidence interval of 0.88 - 0.98. There was no significant difference ($X^2=0.01$) between the two time spans. Given the sample of 71 individuals, a survival rate would have to be less than 0.85 for 10,000 animal-days to be significantly different from the overall mean of 0.93. For 40,000 animal-days, a survival rate of less than 0.90 is needed to be significantly different from the overall mean. In this study, approximately 33,000 animal-days were logged in each time period. Therefore, the lack of a significant difference in the survival rates between the time spans does not seem to be related to the power of the statistical test.

White whales

White whales in captivity between 1975-1979 had an annual survival rate of 0.98 with a 95% confidence interval of 0.94-1.00 (Table 2.). The survival rate of animals in the later time span, 1980-1984, was 0.91 ± 0.05 and was not significantly different from the earlier time span ($X^2=3.14$). The pooled annual survival rate for both periods was 0.94 (0.91- 0.97). A survival rate of less than 0.86 for 10,000 animal-days and less than 0.92 for 50,000 would have been needed to result in a significant difference. The number of animal-days in captivity for each time span for this species was 29,358 and 45,142, respectively. Therefore, the lack of a significant difference in the survival rate between the time spans may be related to the power of the statistical test.

Bottlenose dolphins

The survival rates for animals in captivity between 1975-1979 and 1980-1984 were significantly different ($X^2=12.58$). The annual survival rates were 0.91 and 0.94, respectively. The

pooled annual survival rate was 0.92 with a 95% confidence interval of 0.92-0.93 (Table 3).

The indication that the survival rate varied between the two time spans led to further investigations into the cause of this difference. A significant difference ($X^2=9.00$) was noted for female annual survival rates between the two time spans, while male survival rates did not differ between the two time spans ($X^2=0.56$). This suggests that improvements in the husbandry practices involving female bottlenose dolphins were primarily responsible for the difference in the survival rate between the two periods (Table 4.).

When survival rates were stratified by taketype, survival rates of captive born animals were not significantly different between the time spans. A total of 82,984 animal-days were accumulated in the ten year period (7.5 percent of the total animal-days in the study). Survival of permanently held animals significantly increased ($X^2=19.40$) from 0.91 to 0.95 between the time spans (Table 5.). The HP grouping consisted of 818,304 animal-days for the ten year period (74 percent of the total animal-days in the study). The survival rate of females that were held permanently increased significantly over time ($X^2=13.67$), while survival of permanently held males did not change over time (Table 6.).

DISCUSSION

DeMaster and Drevenak (1988) compared the survival rates for individuals held in captivity between 1953 and 1985 and the survival rate of those individuals acquired since 1975. They reported no significant difference. They further noted that an analysis of survival patterns in captive animals before 1975 might be biased because of incomplete reporting practices. Therefore, DeMaster and Drevenak (1988) pooled all animal-days without any consideration of temporal differences in survival patterns for bottlenose dolphins in captivity. Given the results of this study, it is recommended that in evaluating husbandry practices in the future, only the most recent data be used, given a reasonable sample size is available.

Bigg and Wolman (1975) reported annual survival rates for both immature and mature killer whales (Orcinus orca) based on animals caught between 1964-1970 and held for up to three years in captivity. The annual survival rates in Bigg and Wolman reflect the survival of recently acquired animals in their first, second, and third year held in captivity. This stratification of survival would cause a decrease in sample size over time and tend to weight early years disproportionately. This is likely to negatively bias estimates of survival because survival of newly acquired animals is thought to be less than the survival of acclimated animals. This is in agreement with the results of

DeMaster and Drevenak (1988), Greenwood and Taylor (1985), and Best and Ross (1984), all of which reported lower survival rates in the first year of life or captivity.

The power of the test statistic is related to the total number of animal days in the sample. The smaller the number of animal days the less reliable or powerful the test is in detecting a difference in the survival rates between two time spans. For a binomially distributed random variable, the distribution of a small sample would be broad and flat. This creates a large area where the two distributions overlap; thus creating problems in comparing two such distributions.

The comparison of two five year spans of survival rates for killer whales and white whales utilized a small number of animal-days which might tend to cause a problem with the power of the statistical test. For killer whales a survival rate change of more than 0.05 from the overall mean of 0.93 is needed to show a significant difference. The confidence interval for survival rates for killer whales differed by 0.0038. The difference between survival rates for the two spans for white whales was 0.06. A change of more than 0.07 from the overall mean of 0.94 is needed for a significant difference between the time spans.

Therefore, the lack of a significant difference in the survival rates of captive killer whales and white whales indicates that no major changes in husbandry practices, facility or the capture and acclimation process had occurred within either of the time spans. The actual number of animal-days had increased over time, but this would not bias the results.

Published records show that between 1962 and 1973, 263 killer whales were taken, 50 of which were distributed to oceanaria (Bigg and Wolman, 1975). After 1973, the catch efforts stopped during the moratorium following the introduction of the Marine Mammal Protection Act of 1972. Greenwood and Taylor (1985) stated killer whales in captivity are clearly capable of living for long periods provided that they adapt to captivity over the first two years. Like smaller dolphins, once they have survived this period, their survival rates tend to stabilize. This stability may account for the lack of a significant difference seen in this study which used only those animals living in captivity after 1975, leaving at least a two year period after the moratorium for most of the whales.

Bottlenose dolphins showed a significant difference in the survival rates between the time spans with an increase in the second span. This increase indicates that captive care had improved over the study period. The significant increase between the time spans was evident for females and for permanently held females suggesting a change had possibly occurred in the capture and acclimation process of female bottlenose dolphins. More

likely, however, is Greenwood and Taylor's (1985) explanation that this is due to an increasing hardness of captive cetaceans over time.

Finally, one problem with the Marine Mammal Inventory Report needs to be addressed. The animals taken under old permits (permits that did not need to be re-applied for) were not recorded as being transferred when in fact they no longer resided at the recorded institute. Consequently, these animals were not listed as being housed by a different institution. The gap in this information may lead to an error in calculating an institute's survival rate.

ACKNOWLEDGEMENTS

I would like to thank all those who helped me along through the whole project. Also, I would like to thank those who made this internship possible. Thank you especially to Dr. Douglas DeMaster.

LITERATURE CITED

- Best, P. B. and G. J. B. Ross. 1984. Live-capture fishery for small cetaceans in South African waters. Report of the International Whaling Commission 34: 615-618.
- Bigg, M. A. and A. A. Wolman. 1975. Live-capture killer whale (Orcinus orca) fishery, British Columbia and Washington, 1962-73. Journal of the Fisheries Research Board of Canada 32:1213- 1221.
- DeMaster, D. P. and J. K. Drevenak. 1988. Survivorship patterns in three species of captive cetaceans. Marine Mammal Science. In press.
- Greenwood, A. G. and D. C. Taylor. 1985. Captive killer whales in Europe. Aquatic Mammals 1: 10- 12.
- Hui, C. A. and S. H. Ridgway. 1978. Survivorship patterns in captive killer whales (Orcinus orca). Bulletin of the Southern California Academy of Sciences 77(2):45-51.
- Mayfield, H. 1975. Suggestions for calculating nest success. Wilson Bulletin 87:456-466.
- Poole, L., M. Borchers, and D. M. Castlewitz. 1981. Some Common BASIC Programs: Apple II Edition. Osborne/McGraw Hill, Berkeley, CA. 201 pp.
- Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods. Iowa State University Press. Iowa. 593 pp.
- Trent, T. T. and O. J. Rongstad. 1974. Home range and survival of cottontail rabbits in southwestern Wisconsin. Journal of Wildlife Management 38(3): 459-472.
- Walker, W. A. 1975. Review of the live-capture fishery for smaller cetaceans taken in southern California waters for public display, 1966-1973. Journal of the Fisheries Research Board of Canada 32: 1197- 1211.
- Wimer, M. C. 1988. Areal survivorship patterns of captive California sea lions. Southwest Fisheries Center in-house report. 7pp.

TABLES

TABLE 1. SUMMARY OF THE FIVE YEAR COMPARISON OF SURVIVAL RATES FOR CAPTIVE KILLER WHALES. DATA ARE FROM THE NATIONAL MARINE FISHERIES SERVICE'S MARINE MAMMAL INVENTORY REPORT.

<u>TIME SPAN</u>	<u>DAYS ALIVE IN CAPTIVITY</u>	<u>DAYS DEAD</u>	<u>DAILY SURVIVAL</u>	<u>ANNUAL SURVIVAL</u>	<u>95% CONFIDENCE</u>
75-79	31364	6	0.9998	0.9325	0.88-0.99
80-84	34570	7	0.9998	0.9287	0.88-0.98
75-84	65934	13	0.9998	0.9305	0.90-0.97

TABLE 2. SUMMARY OF THE FIVE YEAR COMPARISON OF SURVIVAL RATES FOR CAPTIVE WHITE WHALES. DATA ARE FROM THE NATIONAL MARINE FISHERIES SERVICE'S MARINE MAMMALS INVENTORY REPORT.

<u>TIME SPAN</u>	<u>DAYS ALIVE IN CAPTIVITY</u>	<u>DAYS DEAD</u>	<u>DAILY SURVIVAL</u>	<u>ANNUAL SURVIVAL</u>	<u>95% CONFIDENCE</u>
75-79	29358	2	0.9999	0.9754	0.94-1.00
80-84	45142	11	0.9998	0.9148	0.87-0.96
75-84	74500	13	0.9998	0.9382	0.91-0.97

TABLE 3. SUMMARY OF THE FIVE YEAR COMPARISON OF SURVIVAL RATES FOR CAPTIVE BOTTLENOSE DOLPHINS. DATA ARE FROM THE NATIONAL MARINE FISHERIES SERVICE'S MARINE MAMMAL INVENTORY REPORT.

<u>TIME SPAN</u>	<u>DAYS ALIVE IN CAPTIVITY</u>	<u>DAYS DEAD</u>	<u>DAILY SURVIVAL</u>	<u>ANNUAL SURVIVAL</u>	<u>95% CONFIDENCE</u>
75-79	465433	127	0.9997	0.9051	0.89-0.92
80-84	642388	111	0.9998	0.9388	0.93-0.95
75-84	1107821	238	0.9998	0.9245	0.92-0.93

TABLE 4. A COMPARISON OF SURVIVAL RATES OVER TWO FIVE YEAR TIME SPANS ANALYSIS FOR CAPTIVE BOTTLENOSE DOLPHINS BY SEX*. DATA ARE FROM THE NATIONAL MARINE FISHERIES SERVICE'S MARINE MAMMAL INVENTORY REPORT.

<u>TIME SPAN</u>	<u>DAYS ALIVE IN CAPTIVITY</u>	<u>DEAD DAYS</u>	<u>ANNUAL SURVIVAL</u>	<u>X² VALUE</u>	<u>SIGNIFICANT DIFFERENCE**</u>
MALES					
75-79	196783	43	0.9233	0.5617	NO
80-84	257072	48	0.9341		
FEMALES					
75-79	265450	72	0.9057	8.9981	YES
80-84	382257	62	0.9425		

*There were 6259 unidentified animal days in this sample of which 13 were dead days.

**When compared to the overall mean with $P > .05$.

TABLE 5. A COMPARISON OF SURVIVAL RATES OVER TWO FIVE YEAR TIME SPANS FOR CAPTIVE BOTTLENOSE DOLPHINS BY TAKETYPE. DATA ARE FROM THE NATIONAL MARINE FISHERIES SERVICE'S MARINE MAMMAL INVENTORY REPORT.

<u>TIME SPAN</u>	<u>DAYS ALIVE IN CAPTIVITY</u>	<u>DEAD DAYS</u>	<u>ANNUAL SURVIVAL</u>	<u>X² VALUE</u>	<u>SIGNIFICANT DIFFERENCE**</u>
CAPTIVE BORN					
75-79	23152	9	0.8155	0.8129	NO
80-84	59807	16	0.9052		
HELD PERMANENTLY					
75-79	372194	100	0.9065	19.403	YES
80-84	445951	59	0.9528		

TABLE 6. A COMPARISON OF SURVIVAL RATES OVER TWO FIVE YEAR TIME SPANS FOR CAPTIVE BOTTLENOSE DOLPHINS BY TAKETYPE AND SEX. DATA ARE FROM THE NATIONAL MARINE FISHERIES SERVICE'S MARINE MAMMAL INVENTORY REPORT.

<u>TIME SPAN</u>	<u>DAYS ALIVE IN CAPTIVITY</u>	<u>DEAD DAYS</u>	<u>ANNUAL SURVIVAL</u>	<u>X² VALUE</u>	<u>SIGNIFICANT DIFFERENCE**</u>
HELD PERMANENTLY MALE					
75-79	155554	30	0.9320	2.3036	NO
80-84	181090	23	0.9547		
HELD PERMANENTLY FEMALE					
75-79	213582	62	0.8994	13.669	YES
80-84	264324	36	0.9515		

APPENDICES

DBASE III PLUS PROGRAMS USED IN THIS STUDY.

Appendix 1

NAME: SETDATA.PRG

PURPOSE: This program transfers information from the original database into a database called GROUP.DBF.

PROGRAM:

```
    set talk off
    Select 1
        use ELF.DBF
    Select 2
        use GROUP.DBF
```

```
select 1
    DO WHILE .NOT. EOF()
        a=monthin
        b=dayin
        c=yearin
        d=monthout
        e=dayout
        f=yearout
        i=institute
        s=sex
        tt=taketype
        ktb=dead
```

```
select 2
    APPEND BLANK
    REPLACE monthin with a, dayin with b, yearin with c
    REPLACE monthout with d, dayout with e, yearout with f
    REPLACE institute with i, dead with ktb, sex with s
    REPLACE taketype with tt
```

```
select 1
SKIP
ENDDO
CLOSE DATABASES
```

Appendix 2

NAME: TIMESPAN.PRG

PURPOSE: This program divides the survival dates into two time spans, 1975-1979 and 1980-1984.

PROGRAM:

```
set talk off
Select 1
use GROUP.DBF
```

```
select 1
```

```
DO WHILE .NOT. EOF()
```

```
DO CASE
```

```
  CASE yearout<75
```

```
  CASE yearin<75
```

```
    IF yearout<84
```

```
      REPLACE monthin with 1, dayin with 1, yearin with 75
```

```
    ELSE
```

```
      REPLACE monthin with 1, dayin with 1, yearin with 75
```

```
      REPLACE monthout with 12, dayout with 31, yearout with 84
```

```
    ENDIF
```

```
  CASE yearin>84
```

```
  CASE yearout>84
```

```
    REPLACE monthout with 12, dayout with 31, yearout with 84
```

```
ENDCASE
```

```
DO CASE
```

```
  CASE yearout<75
```

```
  CASE yearin>84
```

```
  CASE yearin=75
```

```
    IF yearout<80
```

```
      REPLACE amin with monthin, adin with dayin, ayrin with  
      yearin
```

```
      REPLACE amout with monthout, adout with dayout, ayrou  
      with yearout
```

```
    ELSE
```

```
      REPLACE amin with monthin, adin with dayin, ayrin with  
      yearin
```

```
      REPLACE amout with 12, adout with 31, ayrou  
      with 79
```

```
      REPLACE bmin with 1, bdin with 1, byrin with 80
```

```
      REPLACE bmout with monthout, bdout with dayout, byrou  
      with yearout
```

```
    ENDIF
```

```
  CASE yearin<80
```

```
    IF yearout>80
```

```
      REPLACE amin with monthin, adin with dayin, ayrin with  
      yearin
```

```
      REPLACE amout with 12, adout with 31, ayrou  
      with 79
```

```
      REPLACE bmin with 1, bdin with 1, byrin with 80
```


Appendix 2 (continued)

```
        REPLACE bmout with monthout, bdout with dayout, byrout  
            with yearout  
    ELSE  
        REPLACE amin with monthin, adin with dayin, ayrin with  
            yearin  
        REPLACE amout with monthout, adout with dayout, ayrout  
            with yearout  
    ENDIF  
CASE yearin>79  
    REPLACE bmin with monthin, bdin with dayin, byrin with  
        yearin  
    REPLACE bmout with monthout, bdout with dayout, byrout  
        with yearout  
ENDCASE  
SKIP  
ENDDO  
CLOSE DATABASES
```

Appendix 3

NAME: DATEDIF.PRG

PURPOSE: This program assists in the calculation of the number of daysalive in each time span.

PROGRAM:

```
    set talk off
    Select 1
        use GROUP.DBF
    PUBLIC z, year, month, day

select 1
    DO WHILE .NOT. EOF()
        IF yearout<75 .OR. yearin>79
            REPLACE group75_79 with 0
        ELSE
            month=amout
            day=adout
            year=ayrout
            DO DAYS WITH month, day, year
            tdaya=z
            z=0
            month=amin
            day=adin
            year=ayrin
            DO DAYS WITH month, day, year
            tdaysa=tdaya-z
            REPLACE group75_79 with tdaysa
            z=0
        ENDIF

        IF yearin>84 .OR. yearout<75
            REPLACE group80_84 with 0
        ELSE
            month=bmout
            day=bdout
            year=byrout
            DO DAYS WITH month, day, year
            tdayb=z
            z=0
            month=bmin
            day=bdin
            year=byrin
            DO DAYS WITH month, day, year
            tdaysb=tdayb-z
            REPLACE group80_84 with tdaysb
            z=0
        ENDIF

    SKIP
    ENDDO
CLOSE DATABASES
```


Appendix 4

NAME: DAYS.PRG

PURPOSE: This program calculates the number of days for a date.
It is to be used with DATEDIF.PRG.

PROGRAM:

PARAMETERS month, day, year

DO CASE

CASE month=1

z=0

CASE month=2

z=31

CASE month=3

z=59

CASE month=4

z=90

CASE month=5

z=120

CASE month=6

z=151

CASE month=7

z=181

CASE month=8

z=212

CASE month=9

z=243

CASE month=10

z=273

CASE month=11

z=304

CASE month=12

z=334

ENDCASE

z=z+(365*year)+(year/4)+day+1-(year/100)+(year/400)

RETURN

Appendix 5

NAME: STATS.PRG

PURPOSE: This program separates the grouped data and creates a new database file called STAT.DBF.

PROGRAM:

```

    set talk off
    Select 1
        use GROUP.DBF
    Select 2
        use STAT.DBF

select 1
    y=0
    d=0
    xa=0
    xb=0
DO WHILE .NOT. EOF()
    i=institute
    tt=taketype
    s=sex
    ktb=dead
    IF group75_79<>0
        xa=group75_79
        IF ayROUT=79 .and. amout=12 .and. adout=31
            y=0
        ELSE
            y=ktb
        ENDIF
    ENDIF
    IF group80_84<>0
        xb=group80_84
        IF byROUT=84 .and. bmout=12 .and. bdout=31
            d=0
        ELSE
            d=ktb
        ENDIF
    ENDIF
select 2
    APPEND BLANK
    REPLACE sex with s, institute with i, taketype with tt
    REPLACE group75_79 with xa, dead75 with y
    REPLACE group80_84 with xb, dead80 with d
select 1
    xa=0
    xb=0
    y=0
    d=0
SKIP
ENDDO
CLOSE DATABASES

```

Appendix 6

NAME: SUMSTATS.PRG

PURPOSE: This program sums the grouped data from STAT.DBF and transfers the data to SUM.DBF where the chi-square test is then applied.

PROGRAM:

set talk off

Select 1

use STAT.DBF

Select 2

use SUM.DBF

select 1

GOTO TOP

SUM group75_79 with na

SUM group80_84 with nb

SUM dead75 to aa

SUM dead80 to bb

select 2

APPEND BLANK

REPLACE daysalive with na

REPLACE group with "75-79"

REPLACE dead with aa

APPEND BLANK

REPLACE daysalive with nb

REPLACE group with "80-84"

REPLACE dead with bb

GOTO TOP

DO WHILE .NOT. EOF()

dscr=1-dead/daysalive

asr=dscr^365.25

REPLACE dailyshr with dscr

REPLACE annualshr with asr

SKIP

ENDDO

THIS PART IS THE HOMOGENEITY TEST (CHI-SQUARE).

d1=0

d2=0

GOTO TOP

DO WHILE .NOT. EOF()

d1=dead

tot1=daysalive

tot2=tot-tot1

d2=d-d1

chsq=(d1^2/tot1+d2^2/tot2-d^2/tot)/(d/tot)*(1-d/tot)

REPLACE chisqr with chsq

IF chsq>3.84

REPLACE sign with "*"

ENDIF

SKIP

ENDDO

CLOSE DATABASES

